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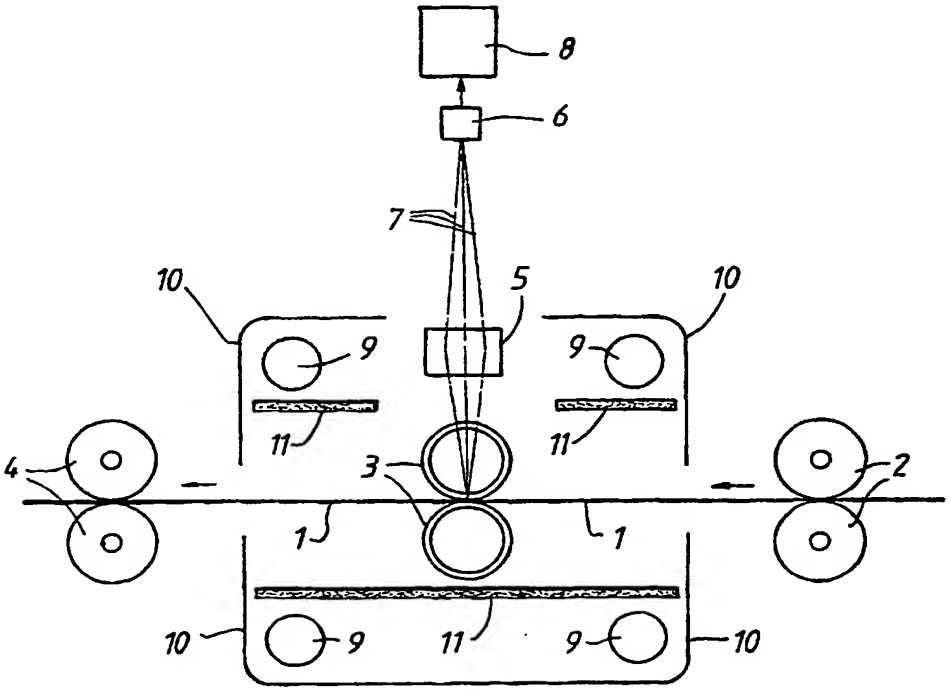
(54) Title: INSTRUMENT FOR ON-LINE DETECTION OF COLOURED CONTAMINANTS IN WHITE FIBRE MASS

(57) Abstract

An instrument for detection of coloured fibres in a white fibre mass is disclosed which comprises drafting rollers (2) and (4) for reducing the fibre mass to a thin web, a pair of transparent cylindrical rollers (3) between which the web passes and an optical inspection device (6, 8) for detecting coloured fibres in the web. An upper of the rollers (3) comprises a cylindrical lens and together with a focussing lens (5), focuses light from the fibre mass to a linear diode array (6) of the inspection device (6, 8). Output signals from the diode array (6) are received by a computer (8) of the inspection device for detecting coloured fibres. Balanced illumination provided by light sources (9), reflectors (10) and diffused transmitters (11) provide balanced illumination to the web to suppress background images formed by the white fibre mass.



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INSTRUMENT FOR ON-LINE DETECTION OF COLOURED CONTAMINANTS IN WHITE FIBRE MASS

The present invention relates generally to the detection of contaminants in assemblies of fibres and particularly, but not exclusively, to the detection of coloured fibres in wool top.

The presence of coloured fibre contaminants in light coloured woollen fabrics has a deleterious effect on their aesthetic appearance. Consequently the contamination of white wool by coloured fibres, even at concentrations as low as ten coloured fibres per one million white fibres, can cause a substantial depreciation in the commercial value of wool especially if it is destined for white or pastel end-uses. The detection of coloured fibres in wool is therefore of considerable economic importance to specialist groups in the textile industry and many attempts have been made to develop efficient and reliable detection methods.

First generation methods involving visual inspection of top by a human observer are very slow and laborious and dependent on the skill and concentration of the observer. The introduction of improved image sensors and image processing techniques has now made possible the development of a second generation of instruments such as the present invention which can provide rapid automatic detection of coloured fibres in top.

The prior art in the field of this invention can be characterised by the following features:

(i) A drafting stage.

A sample of the white fibre mass containing coloured fibre contaminants is reduced to an open web to expose all fibres to view before inspection is carried out, e.g. the web may be formed by roller drafting or simply

spread by hand.

(ii) A stage of optical inspection.

This stage comprises a source of illumination, a viewing support for the fibre web, and a lens system to focus the fibre images onto a light detector. This detector must be able to resolve the images of individual fibres and may be the retina in the eye of an observer, a photo-diode array or a photographic emulsion.

(iii) A means for suppression of background images.

The individual fibres in a white fibre mass are essentially transparent to visible light and, when back-lit by a luminous source, are made visible by the formation of images whose boundaries are darker than the source of illumination. The net result is that background images formed by the white fibre mass may obscure the coloured fibre images, making the detection of pale coloured fibres especially difficult.

For efficient detection of coloured fibres it is essential to suppress these background images. This has been performed in the following ways in prior art arrangements known to the applicants:

Liquid Immersion

The fibre mass is immersed in a transparent liquid with a refractive index close to that of the fibres so that reflection and refraction of light at the liquid-fibre interfaces is almost completely eliminated. Under these conditions, fibres can be distinguished against the background illumination only by virtue of their absorption properties, so the white fibre background is suppressed.

Balanced Illumination

The fibre mass is illuminated in air by diffuse sources located on both sides of the web. A suitable balance of illumination between the opposed sources can be chosen so that the image boundaries appear to have the same

brightness as the background illumination, i.e. the white fibre mass becomes invisible.

The following combinations of the above features are known to the applicants:

(1) Visual inspection with liquid immersion.

The web is immersed in a liquid of matching refractive index and then compressed beneath a glass plate for inspection. This method provides very good suppression of background images but the inspection rate is extremely slow and the detection efficiency is dependent on the visual acuity and concentration of the observer. Furthermore, many immersion liquids with a suitable refractive index are toxic or highly inflammable and strict safety procedures must be observed during their use.

(2) Automated inspection with liquid immersion.

An instrument which uses the liquid immersion technique during the automated inspection of fibrous materials has been described in UK Patent Application. GB 2,107,858A. A fibre web is transported through an inspection region located between a pair of horizontal plates immersed in benzyl alcohol. The upper plate is transparent and an image of the web is focussed onto a light detector consisting of an array of photo-diodes coupled to a computer. To allow free passage of the web between the plates, a separation of approximately 2 mm is required, and this greatly exceeds the depth of field of the optical system. Consequently, special provision must be made to scan the web in depth as it passes between the plates.

(3) Visual inspection in air with balanced illumination.

A variety of viewing supports and sources of illumination have been reported using the balanced illumination method; e.g. the web is supported in air by a

translucent plate or compressed between two transparent plates, and then illuminated from both sides by diffuse sources of light. The location and brightness of the sources are chosen to provide optimum suppression of the images formed by the white fibre mass. Again, in common with the other visual inspection methods, the inspection rate is slow and the efficiency of detection of coloured fibre contaminants is dependent on the observer.

The present invention provides an instrument for detection of coloured contaminants in a white fibre mass, including:

a pair of substantially parallel spaced apart transparent rollers defining therebetween a fibre mass path;

an illumination system for providing substantially balanced illumination on both sides of the fibre mass path; and

a light detector for viewing the fibre mass through one of the transparent rollers to provide an indication of coloured contaminants in the fibre mass.

In a preferred embodiment of the invention a sample of the white fibre mass is reduced to a plane web by roller drafting and then transported through an inspection region which is located between two transparent rollers. The thickness of the web in the inspection region is controlled by the roller separation to ensure that all fibres in this region remain within the depth of the field of the optical system.

A focussing lens mounted above the upper roller projects the fibre images onto a light detector, preferably an array of photo-diodes, whose output signals are processed by a computer to identify coloured contaminants such as coloured fibres. The upper roller behaves as a weak cylindrical lens and therefore forms part of the imaging system. To minimise cylindrical distortion, the upper roller is

constructed in the form of a thin-walled cylinder with an annular cross-section and the inspection region is confined to a narrow transverse strip centred about the contact line between the rollers. In the preferred embodiment of the invention the lower roller also has the form of a hollow cylinder but it is not part of the imaging system and, in an alternative form of the invention, a solid transportation roller could be used with equal efficacy.

Diffuse sources of illumination located above and below the transparent rollers preferably form the illumination system and are used to suppress the background images formed by the white fibre mass. The brightness and location of these sources may be adjusted to provide the balanced illumination required for optimum suppression conditions.

The invention will be understood more clearly by reference to the accompanying drawings which describe, by way of example, a preferred embodiment.

Figure 1 is a schematic sectional view of the optical and transport sections of the invention in a plane normal to the roller axis.

Figure 2 is a schematic sectional view of the invention in the plane containing the axes of both transparent rollers.

The preferred apparatus of this invention is shown schematically in Figures 1 and 2. A roller drafting unit is used to reduce a sample of wool, usually in the form of top sliver, to a web with a linear density of approximately 2 ktex and a width of approximately 50 mm. The web (1) enters the optical system from the feed rollers of the drafting unit (2), passes through the inspection region between the transparent rollers (3), and then leaves the apparatus through a pair of exit rollers (4).

The apparatus also contains an optical inspection system which consists of a weak cylindrical lens formed by the upper transparent roller and a focussing lens (5) located between the upper roller and the light detector (6). Paths of light rays (7) through the optical system are shown schematically in Figures 1 and 2.

In a preferred embodiment, the upper transparent roller is constructed from thin-walled glass tubing with an outside diameter of 46 mm and a wall thickness of 1.5 mm in order to minimise cylindrical distortion in the image. The focussing lens, e.g. a photographic objective with an adjustable aperture, is positioned above the upper transparent roller so that it projects the image of the inspection region onto the light detector with a magnification factor approximately in the range 0.5 to 2. The depth of field of the optical system and the resolution of spatial features in the web are determined by the aperture of the focussing lens. Tests have shown that this optical system can resolve features in the web separated by at least 6 μm when observations are confined to a narrow strip extending no further than 2 mm on either side of the roller contact line. A field of view with this shape is ideally suited to the detection of images by a sensor with the form of a linear array.

The light detector (6) in the present description of the exemplary embodiment of the invention is a linear array of photo-diodes which produces an electronic image of the inspection strip as the web is fed between the transparent rollers. The output signal from each photo-diode element is sampled in sequence to build up a digital representation of the image which is then processed by a computer (8) to detect the presence of coloured fibre contaminants.

The preferred embodiment of the invention may also include apparatus to provide balanced illumination of the fibre

sample. This apparatus comprises sources of diffuse light (9), located above and below the web, which are backed by diffusely reflecting materials (10) and screened from the web by diffusely transmitting materials (11). The mutual disposition of these components and the brightness of the sources are chosen to provide optimum suppression of the background images formed by the white fibre mass.

Thus, at least in the preferred embodiments of the invention, the following advantages may be gained:

(1) The use of transparent rollers allows continuous inspection of the white fibre mass for optical defects, e.g. coloured fibre contaminants in wool tops.

(2) Tests have shown that the combination of balanced illumination with transparent rollers provides excellent suppression of background fibre images. Furthermore, the inspection is carried out in air without the need to immerse the web in a liquid of matching refractive index. This means that practical problems associated with the handling and toxicity of immersion liquids are avoided.

(3) The thickness of the web between the transparent rollers is readily controlled by adjustment of the roller separation so that all fibres remain within the depth of field of the optical system.

(4) The optical system, comprising the upper transparent roller and the focussing lens, provides the high quality images required for the detection of coloured fibres in a web of white fibres; e.g. tests have shown that this optical system can resolve features in the web separated by at least 6 μm when observations are confined to a narrow strip extending no further than 2 mm on either side of the roller contact line. A field of view with this shape is ideally suited to the detection of images with a sensor such as a linear photo-diode array.

(5) The setting of the separation between the transparent rollers allows fibres in the inspection region to remain within the depth of field of the optical system. In addition, the use of balanced illumination in the present invention allows the web to be inspected in air without exposing the operator to hazards associated with many commonly used immersion liquids.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An instrument for detection of coloured contaminants in a white fibre mass, including:

a pair of substantially parallel spaced apart transparent rollers defining therebetween a fibre mass path;

an illumination system for providing substantially balanced illumination on both sides of the fibre mass path; and

a light detector for viewing the fibre mass through one of the transparent rollers to provide an indication of coloured contaminants in the fibre mass.

2. The instrument of claim 1 further including roller drafting means for reducing the fibre mass to a plane web so that the plane web is fed to the transparent rollers.

3. The instrument of claim 1 wherein the fibre mass, in an inspection region between the rollers, has a thickness controlled by spacing of the rollers to ensure the fibres remain within the depth of field of the optical inspection device.

4. The instrument of claim 1 wherein the light detector includes an array of photodiodes for producing output signals, and the instrument further including processing means for receiving the output signals to identify coloured contaminants.

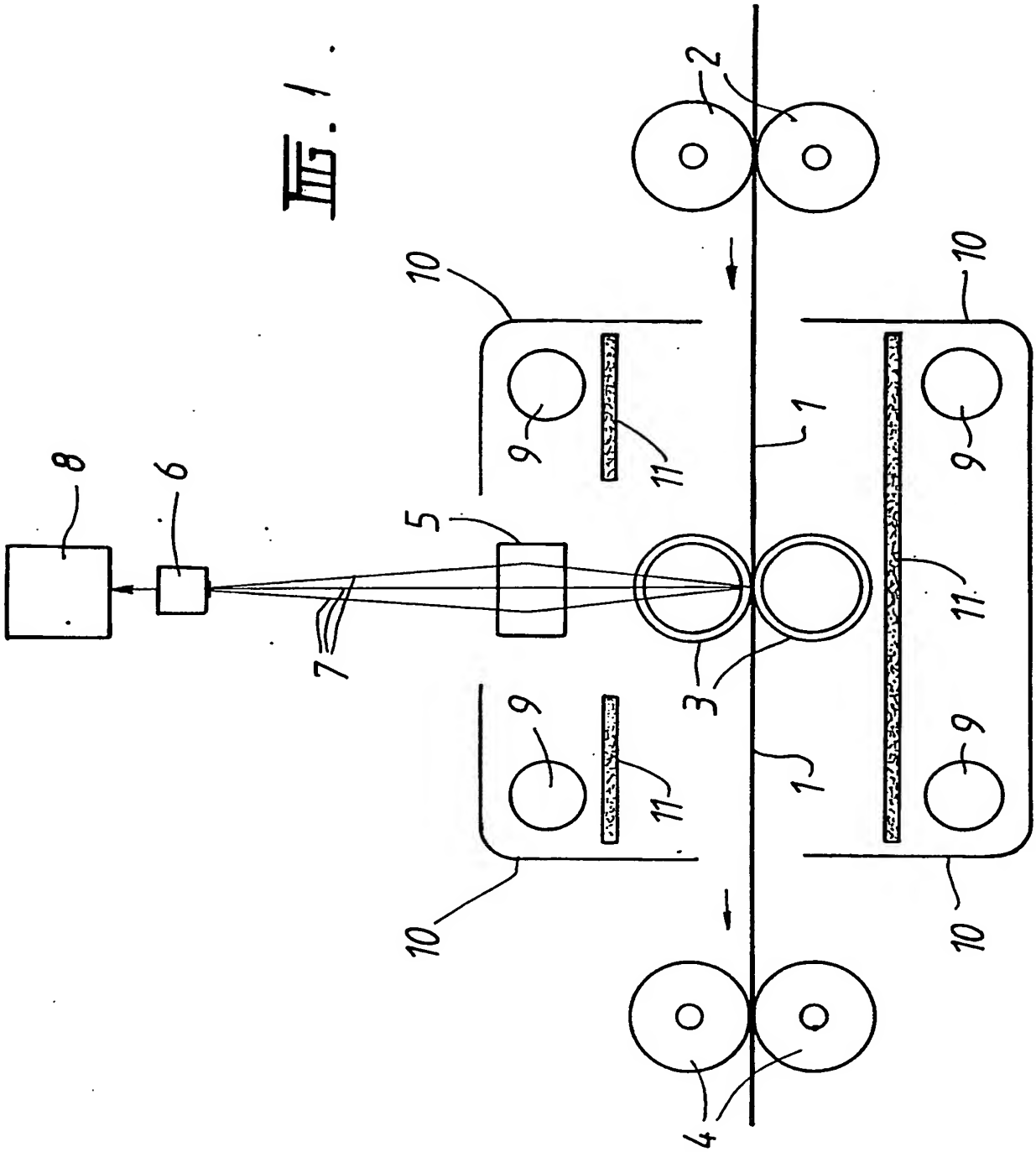
5. The instrument of claim 1 wherein the roller through which the fibre mass is viewed is a thin walled cylindrical roller.

6. The instrument of claim 1 wherein an imaging system is disposed between the fibre mass and the light

detector, the imaging system comprising the roller through which the fibre mass is viewed which forms a weak cylindrical lens, and a focussing lens disposed between the roller and the optical inspection device.

7. The instrument of claim 1 wherein the instrument performs continuous inspection of a white fibre mass.

Fig. 1.



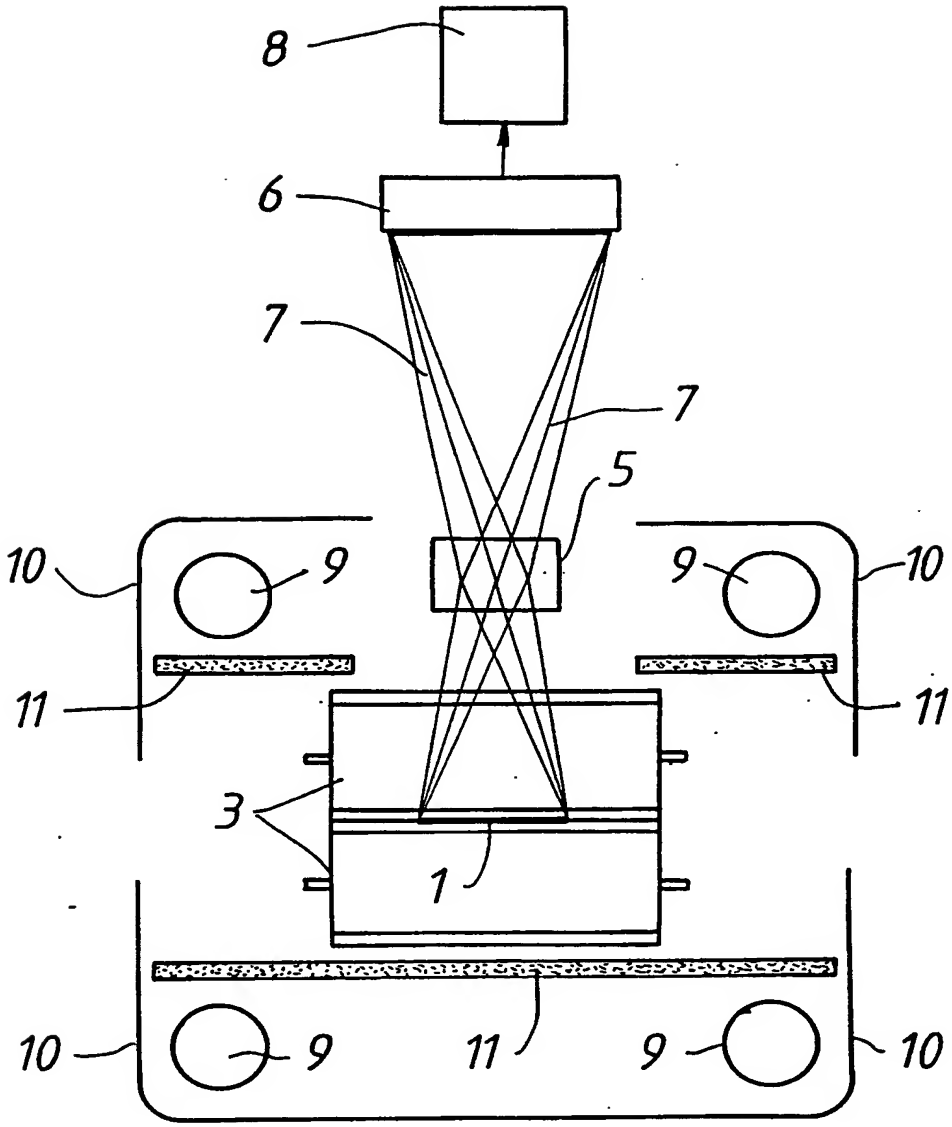


FIG. 2.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 94/00759

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[6] G01N 21/89, 33/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC G01N 21/30, 21/32, 21/88, 21/89, 33/36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X,Y	DE,A, 2836280 (ERWIN SICK GmbH) 21 February 1980 (21.02.80) Fig 1 and description	1,6,7
Y	GB,A, 2095828 (WOOL DEVELOPMENT INTERNATIONAL LIMITED) 6 October 1982 (06.10.82) Fig 1 and Abstract	1,7
A	GB,A, 2107858 (WOOL DEVELOPMENT INTERNATIONAL LIMITED) 5 May 1983 (05.05.83)	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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1 March 1995 (01.03.95)	9 Mar 1995 (09.03.95)

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	EP,A, 226430 (UNISEARCH LIMITED) 24 June 1987 (24.06.87)	
A	AU,A, 35215/93 (SCOTSDALE RESOURCES PTY LTD) 16 September 1993 (16.09.93)	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member
GB 2095828	BE 892720 CH 654608
EP 226430	AU 66403/86
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